Due On: ________________ Name: ___________________________

AP Physics 1: Review Packet 03

Problem 1: For each case, draw and label the forces (not components) acting on the object. Each arrow must start on the white dot and be straight. Then write one or more equations relating the forces on the object. Finally, rank the three forces in the blanks. Acceptable labels are F_W (or F_g or mg), F_N, F_f, F_T, and $F_{applied}$.

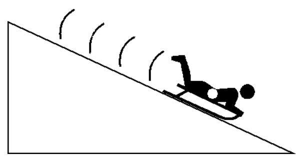
(a) Car slows down (3 forces)

Net Force Equation: _____________________

Balanced Forces Equation: _____________________

Rank the forces: _____ = _____ > _____

(b) Child has a constant speed (3 forces)

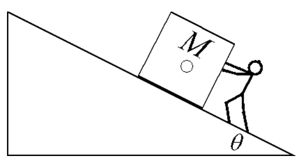


Balanced Forces Equation: _____________________

Balanced Forces Equation: _____________________

Rank the forces: _____ > _____ > _____

(c) Box moves with constant speed (4 forces)

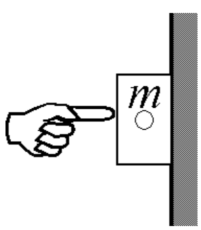


Balanced Forces Equation: _____________________

Balanced Forces Equation: _____________________

Rank the forces: _____ > _____ > _____ > _____

(d) Block held at rest against wall (4 forces)



Balanced Forces Equation: _____________________

Balanced Forces Equation: _____________________

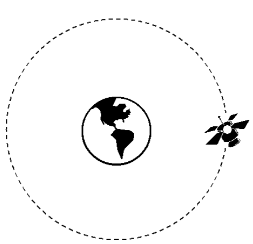
Rank the forces: _____ = _____ > _____ = _____

(e) A man and bicycle go over a hill at constant speed (2 forces)

Net Force Equation: _____________________
(This net force equation must use mv^2/r)

Rank the forces: _____ > _____

(f) The satellite orbits the Earth (1 force)



Net Force Equation: _____________________
(This net force equation must use mv^2/r)

Problem 2: Newton's Third Law is also known as the Law of Action and Reaction. The law says "when *A* pushes *B*, *B* pushes on *A* with the same amount of force but in the opposite direction." A common misconception is that "action" is "cause" and "reaction" is "effect". But it turns out that "action" is a "cause" and "reaction" is another "cause", each having its own effect.

Example: A child jumps and lands on a trampoline.

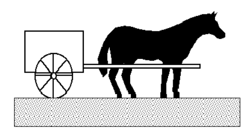
Not action and reaction: As the child lands on the trampoline, the $\underbrace{\text{child pushes down on the trampoline}}_{\text{This IS "action", because it is a cause.}}$ and $\underbrace{\text{the trampoline bends downward}}_{\text{This IS NOT "reaction", because it is an effect.}}$.

This is action and reaction:

	Action	Reaction
Cause	A child exerts a downward force on the trampoline.	The trampoline exerts an upward force on the child.
Effect	The trampoline bows downward.	The child's downward motion stops (or reverses).

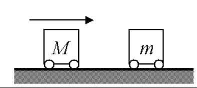
Now you try. Make sure your action has a thing doing the forcing, a thing being forced, and a direction.

(a) A horse-and-wagon are initially at rest. The horse begins to accelerate by walking forward.



	Action	Reaction
Cause	The horse...	The wagon...
Effect	The wagon...	The horse...

(b) A heavy car collides with a light car. The cars don't stick together.



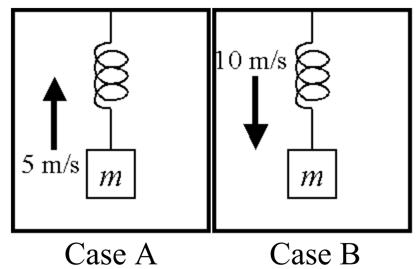
	Action	Reaction
Cause	The heavy car...	The light car...
Effect	The light car...	The heavy car...

(c) A helicopter hovers over the ground. The grass on the ground lies flat due to the airflow under the helicopter.

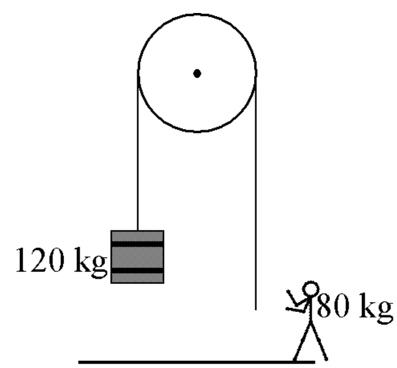
Cause	The helicopter...	The air...
Effect	The air...	The helicopter...

Problem 3: Provide written answers and explanations to the following questions.

(a) A spring is attached to the ceiling of an elevator, and a block of mass M is suspended from the spring. In Case A, the elevator moves upward with a constant speed of 5 m/s. In Case B, the elevator moves downward with a constant speed of 10 m/s. Will the spring be stretched more in Case A, Case B, or is the stretch the same in both cases? Explain your reasoning.

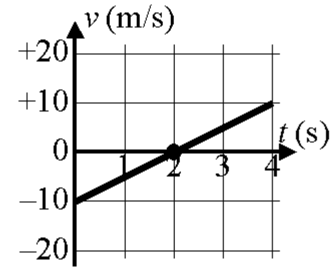


(b) A loaded barrel is attached to a rope that passes around an overhead pulley and is tied to a ring on the floor. Linda, a construction worker, plans to untie the rope from the ring, pull on the barrel to lift it one meter higher, than retie the rope. Linda's mass is 80 kg, she is capable of lifting twice her weight, and the loaded barrel has a mass of 120 kg. Explain what is wrong with Linda's plan.

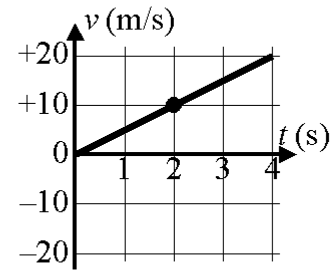


(c) Graphs are shown of the velocity vs. time of two identical train engines on a straight track. A positive velocity represents eastward travel. Both graphs have the same scales. On each graph, time $t = 2$ s is indicated with a dot.

A student makes the following observation: "I think that B has the greater net force acting on the engine at time $t = 2$ sec because the net force on A is zero at that time." What is wrong with the student's statement? What would the correct statement be?

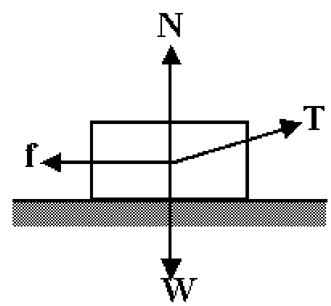


Train A

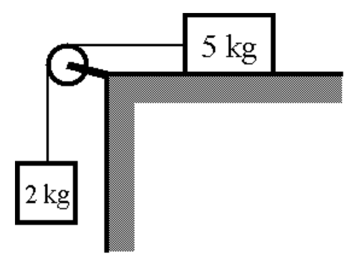


Train B

(d) A person using a rope pulls a heavy slab across a rough horizontal surface at constant speed. The person's applied tension force is T, the object's weight is W, the normal force is N, and the frictional force is f. A student observes this situation and states, "I think that $T = f$ and that $W = N$. Because $f = \mu N$ and $\mu < 1$, the correct ranking of forces must be $W=N > T=f$." Explain what is wrong and what is right about the student's observation. Then write a completely correct sentence relating all of the forces.

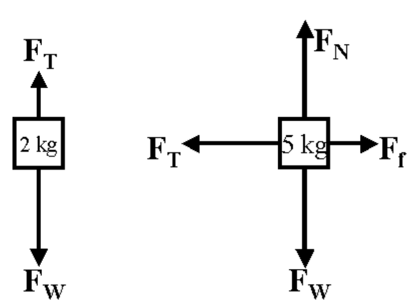


(e) A light rope connects a 5 kg block to a 2 kg hanger. The 5 kg block is on a rough horizontal surface. Someone gives the 5 kg block a sharp push to the right. The free-body diagrams shown indicate the forces <u>after the push</u>. Four students argue over the force diagrams.



A: The 2 kg FBD is wrong. The forces should have the same magnitude.
B: The problem with the 2 kg FBD is that the upward force should be stronger since the 2 kg moves up.
C: The 2 kg is fine but the 5 kg FBD has friction in the wrong direction.

Which student is correct? Explain why and correct the other statements.



Forces and Newton's Laws Review

IMPORTANT QUANTITIES

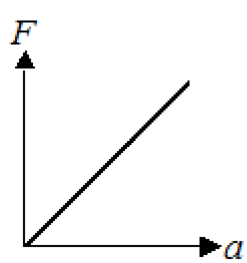
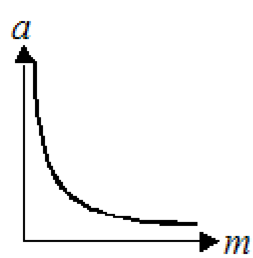
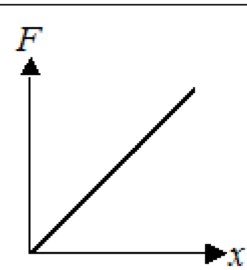
Name	Symbol	Units	Basic Equation
Force	$\mathbf{F}$	N	$\mathbf{F} = m\mathbf{a}$
Tension Force	$\mathbf{F_T}$	N	None
Weight Force	$\mathbf{F_W}$	N	$\mathbf{F}_W = m\mathbf{g}$
Mass	m	kg	None
Spring Constant	k	N/m	None

Name	Symbol	Units	Basic Equation
Normal Force	$\mathbf{F_N}$	N	None
Friction Force	$\mathbf{F_f}$	N	$F_f = \mu F_N$
Spring Force	$\mathbf{F_S}$	N	$\mathbf{F}_S = -k\mathbf{x}$
Coefficient of Friction	μ	None	None

IMPORTANT EQUATIONS

Name	Equation	Given?	Notes
Newton's Second Law (The most important equation in all of physics!)	$\sum \mathbf{F} = m\mathbf{a}$	Yes	For a single force, $\mathbf{F} = m\mathbf{a}$. However, for several forces, it is the **<u>vector sum</u>** of all forces equal mass times acceleration.
Newton's Second Law in terms of components.	$\sum F_x = ma_x$ $\sum F_y = ma_y$	No	If you have a problem taking place in 2D, then you need to create a sum-of-all forces equation for the components in each individual dimension.
Perpendicular Component of Weight on an Inclined Plane	$F_\perp = mg\cos\theta$	No	Usually equal to the normal force on an object on an inclined plane.
Parallel Component of Weight on an Inclined Plane	$F_\parallel = mg\sin\theta$	No	Usually equal to the force "down the plane" of an object on an inclined plane.

IMPORTANT GRAPHS

Name	Graph (Shape)	Notes
Force vs. Acceleration (for a constant mass) AND Acceleration vs. Mass (for a constant force)	 	Slope of F vs. a is mass. As mass increases, acceleration decreases
Force vs. Displacement of a spring		Slope is spring constant k. The area under the graph represents the work done on (and potential energy stored in) the spring.

IMPORTANT CONCEPTS

- Newton's First Law: If the net force on an object is zero (all forces balance), it will move with constant velocity in a straight line. Likewise, if an object travels with constant velocity in a straight line, the net force on the object is zero. Note that an object can be in motion even if it has no net force.
- Newton's Third Law: If object A exerts a force on object B, then object B must exert an equal force (but opposite in direction) on A. Note that action-reaction pairs are always on different objects (they always try to trick you into saying otherwise on the exam). Note also that, since they are on different objects, action-reaction pairs cannot cancel out.
- Weight force is always directed down.
- Only a surface can exert normal force. If there is no surface in the problem, there is no normal force. The normal force is perpendicular (normal) to the surface.
- Only a rope or string can exert tension force. If there is no rope or string in the problem, there is no tension force.
- Normal and tension forces have no basic equations. They can only be found by setting up a statement of Newton's Second Law, and then solving for them.
- A rope exerts the same tension force at both ends, even if it is set through a pulley.
- A scale does not measure mass or weight. It measures the normal force it exerts.
- The negative sign in the spring-force equation only represents that the spring force is always opposite to the displacement of the spring.
- Friction is always parallel to the plane, directed to oppose relative motion. This does not necessarily mean that it is in the opposite direction as velocity. A box in the back of a pick-up truck has friction that prevents it from sliding off of the truck, but that friction is in the same direction as the velocity of the truck.
- Two types of friction: Static friction acts when the object is not sliding on the surface. Kinetic friction acts when the object is sliding on the surface. Both types of friction have separate coefficients of friction, often labeled μ_s and μ_k. Note that $0 < \mu_k < \mu_s < 1$.
- MAJOR NOTE ON FRICTION: The force of friction is $F_f = \mu F_N$. But for static friction, the friction force could be ***less*** than this! This formula only gives the maximum possible static friction!

Big concept: Use forces you are asked to solve for a force or find an object's acceleration.

When dealing with forces in two dimensions, split any force into components that makes a odd angle with the **acceleration vector**:

- All forces and components **perpendicular** to the acceleration **balance** (add to zero).
- All forces and components **parallel** to the acceleration add to mass×acceleration.